ISSN (electrónico): 1699-5198 - ISSN (papel): 0212-1611 - CODEN NUHOEQ S.V.R. 318

ARÁN

Nutrición Hospitalaria

Trabajo Original

Otros

# Executive functions and emotion regulation in obesity and eating disorders

*Funciones ejecutivas y regulación emocional en obesidad y trastornos alimentarios*

Mara Segura-Serralta[1], Conxa Perpiñá[1,2], Sonia Ciscar[3], Lorena Blasco[3], Raúl Espert[1], Cristina Romero-Escobar[4], José Ramón Domínguez[4] and Javier Oltra-Cucarella[1]

*[1]Department of Personality, Evaluation and Psychological Treatment. Faculty of Psychology. Universidad de Valencia. Valencia, Spain. [2]CIBER Fisiopatología de la Obesidad y Nutrición (CIBERobn). Instituto Salud Carlos III. Madrid, Spain. [3]Hospital de La Ribera. Alzira, Valencia. Spain. [4]Hospital Universitario de Sant Joan d'Alacant. Alicante, Spain*

## Abstract

**Introduction:** eating disorders (ED) such as anorexia nervosa (AN) or bulimia nervosa (BN), as well as obesity (OB), are related to emotional and neuropsychological impairments on measures of cognitive flexibility, central coherence or decision making.

However, little is known about the association among emotional regulation, neuropsychological variables and affect.

**Objectives:** to analyze whether neuropsychological and affect variables can predict emotional regulation in ED and in OB.

**Methods:** thirty females with restricting ED (restricting AN) were assessed, 18 with purging ED (purging AN and BN), 33 with OB and 39 healthy controls matched for intelligence. The Wisconsin Card Sorting Test (WCST) assessed cognitive flexibility, the Group Embedded Figures Test (GEFT) assessed central coherence, the Iowa Gambling Task (IGT) assessed decision making, the Positive and Negative Affect Schedule assessed positive (PANAS-PA) and negative (PANAS-NA) affect, and the Difficulties in Emotion Regulation Scale (DERS) assessed emotional regulation.

**Results:** relative to the healthy control group, ED and OB groups performed worse on IGT ($p = 0.002$) and GEFT ($p = 0.003$), had lower scores on PANAS-PA ($p = 0.001$) and higher scores on DERS ($p < 0.001$). ED groups had higher scores on PANAS-NA tan both OB and healthy controls ($p = 0.001$). PANAS-PA, PANAS-NA and IGT accounted for 51.4% of the variance of the DERS ($p < 0.001$).

**Conclusions:** our study shows a significant association between decision making, affect and emotional regulation in the continuum from AN to OB, and also highlights the importance of including programs focused on decision making and affect in cognitive interventions for ED and OB.

**Key words:**

Affect. Anorexia nervosa. Cognitive flexibility. Decision-making. Obesity.

## Resumen

**Introducción:** los trastornos de la conducta alimentaria (TCA) como la anorexia nerviosa (AN) o la bulimia nerviosa (BN), así como la obesidad (OB), se relacionan con alteraciones neuropsicológicas en flexibilidad cognitiva, coherencia central, toma de decisiones y alteraciones emocionales. Sin embargo, se desconoce la asociación entre regulación emocional, variables neuropsicológicas y variables de afecto.

**Objetivos:** analizar si variables neuropsicológicas y afectivas pueden predecir la regulación emocional en los TCA y en la OB.

**Métodos:** se evaluó a 30 mujeres con TCA restrictivo (AN restrictiva), 18 con TCA purgativo (AN purgativa y BN), 33 OB y 39 controles sanas emparejadas por nivel intelectual. El Wisconsin Card Sorting Test (WCST) evaluó la flexibilidad cognitiva; el Group Embedded Figures Test (GEFT), la coherencia central; el Iowa Gambling Task (IGT), la toma de decisiones; el Positive and Negative Affect Schedule, el afecto positivo (PANAS-PA) y negativo (PANAS-NA); y la Difficulties in Emotion Regulation Scale (DERS), la regulación emocional.

**Resultados:** respecto al grupo control, los grupos TCA y OB rindieron peor en IGT ($p = 0{,}002$) y GEFT ($p = 0{,}003$) y presentaron menores puntuaciones en PANAS-PA ($p = 0{,}001$) y mayores en DERS ($p < 0{,}001$). Los grupos TCA puntuaron más alto en PANAS-NA que los grupos OB y control ($p = 0{,}001$). El 51,4% de la varianza del DERS fue explicado por PANAS-PA, PANAS-NA e IGT ($p < 0{,}001$).

**Conclusiones:** nuestro estudio muestra una asociación entre toma de decisiones y afecto con regulación emocional en el continuo de AN a OB e indica la importancia de incluir programas de toma de decisiones y afecto en las intervenciones cognitivas para TCA y para OB.

**Palabras clave:**

Afecto. Anorexia nerviosa. Flexibilidad cognitiva. Toma de decisiones. Obesidad.

Recibido: 27/04/2018 • Aceptado: 13/06/2018

*Funding: This work was supported by the Spanish Ministerio de Ciencia y Tecnología and the Fondo Europeo de Desarrollo Regional (FEDER) (Grant PSI2009/10957); Ministerio de Economía y Competitividad and the Fondo Europeo de Desarrollo Regional (FEDER) (PSI2014-51920-R). Centro de Investigación Biomédica en Red Fisiopatología de la Obesidad y Nutrición is an initiative of ISCIII.*

Segura-Serralta M, Perpiñá C, Ciscar S, Blasco L, Espert R, Romero-Escobar C, Domínguez JR, Oltra-Cucarella J. Executive functions and emotion regulation in obesity and eating disorders. Nutr Hosp 2019;36(1):167-172

DOI: http://dx.doi.org/10.20960/nh.02016

Correspondence:

Conxa Perpiñá. Department of Personality, Evaluation and Psychological Treatment. Faculty of Psychology. University of Valencia. Avda. Blasco Ibáñez, 21. 46010 Valencia, Spain
e-mail: perpinya@uv.es

## INTRODUCTION

Pathological eating behaviors such as restrained eating, overeating, or binge eating are a complex phenomenon where multiple factors intervene. Recent research has hypothesized that in eating disorders (ED), mainly in the restricting-type anorexia nervosa (AN), pathological eating behaviors can be explained by a model of uncontrolled behavior regulated by an aberrant reward system, a theory applied to explain obesity (OB) as an addiction to food (1). The fact that restrained eating is rewarding is indicated by the persistence of dieting to the point of starvation and emaciation, experiences that are seen by patients as positive due to a sense of dominance over hunger and weight or the alleviation of negative affect (2).

Negative emotions are a correlate and unique predictor of self-reported emotional eating urges and binge eating in non-clinical and clinical populations (3). The affect regulation model postulates that negative affect triggers emotional eating, which provides a temporary distraction, emotional numbing, or a sense of comfort, but in the long term this strategy interferes with the ability to learn and implement adaptive strategies for coping with negative emotions (4,5).

Emotional regulation and the approach or inhibited behavior processes are probably associated with the role of executive functions in supervising and regulating eating patterns, but patients with weight and eating-related problems also seem to have executive function difficulties. These patients make wrong decisions when they have to choose whether or not to eat, which food to eat, and how much to eat. Previous research has found that patients with ED or obesity perform worse than healthy controls on tasks assessing decision-making (6). Performance on these tasks is characterized by making decisions based on the short-term consequences (for example, relief of anxiety), despite long-term negative consequences, and by not learning from previous decisions to modify current behavior (7-9). Patients with ED or obesity also show impaired set-shifting abilities (9-11), with difficulties in modifying their behavior and cognition in order to adapt to a changing environment. Difficulties in set-shifting are manifested as a tendency to solve problems rigidly and perform inflexible routines, in perseverative behaviors fixated on specific rules (12), and in the perseveration of restrictive and/or bingeing or purgative behaviors, despite the problems involved and the risks to their physical and psychosocial health.

The cognitive profile of individuals with obesity is similar to that of patients with bulimia nervosa (BN), with set-shifting impairments being related to perseveration in the use of methods that are ineffective in losing weight (13). Another finding related to the executive functions in ED is a deficit in central coherence, specifically, weak central coherence (the tendency to focus excessively on details, with difficulties in integrating elements appropriately in their context) (14). This profile is more evident in patients with AN-restricting type, who show superior detail-focused processing (15,16). This finding is also present in weight-recovered patients with AN (17). Conversely, patients with binge/purge symptomatology (e.g., BN or binge eating disorder [BED]) show impairments in global integration (7,15,16,18). Although central coherence has been addressed less frequently in obesity, studies suggest that patients with obesity or BED show preferences for global processing (7).

In order to analyze both neuropsychological and emotional variables in patients with ED and patients with obesity, this work was carried out with three main objectives: first, to compare performance on neuropsychological tests measuring executive functioning; second, to compare affect and emotional regulation; and third, to analyze the ability of affect and neuropsychological variables to predict emotional regulation.

## METHODS

### PARTICIPANTS

The clinical sample included 81 patients recruited at three hospitals and health centers from (BLINDED), and 39 healthy participants (HCG) with normal weight (BMI 20-24.9) and no mental disorder, recruited from the general population. Thirty-three patients suffered from obesity (OB group), and 48 were patients with ED according to the DSM-5 (19). A panel of psychiatrists and clinical psychologists with expertise in ED assessed diagnostic criteria using the SCID-I (20), as well as inclusion and exclusion criteria at each recruitment site. Patients with ED were included if they: a) were females; b) were aged between 16-60 years; and c) had a diagnosis of any type of ED. Exclusion criteria for healthy controls, patients with ED and patients with OB were intelligence quotient (IQ) scores ≤ 85, presence of drug or alcohol abuse/dependence, a severe mental disorder (e.g., schizophrenia), a history of head injury, neurological disease, neuropsychiatric disorders, and hearing or visual impairment. An additional exclusion criterion for the ED participants was having a BMI above 30, so that BED comorbidity with obesity was ruled out. Obese patients with a current or lifetime diagnosis of an ED were excluded.

From a pool of 163 participants, one was excluded because of IQ scores lower than 85. Forty-two participants were excluded because of missing data, so eventually data were analyzed for 120 participants. There were 16 patients with AN-restricting type, four with AN-binge eating/purging type, eight with BN-purging type, 14 with other specified eating disorder (OSED-AN type), and six with other specified eating disorder (OSED-BN type). To simplify the composition of the analysis of the patient groups, and based on studies interested in the difference in the neuropsychological profile of restrictive/binge-purge symptomatology (7,11,21), participants with ED were divided into two groups. The "restricting group" (RG) included 30 patients (AN-restricting type or OSED-AN type), whereas the "bingeing/purging group" (BPG) included 18 patients (AN-binge eating/purging type, BN-purging type, or OSED-BN type).

The distribution of missing data was completely at random ($c^2$ [44] = 48.31, p = 0.303) according to the Little's Missing Completely At Random test (22), and there were no significant differences between included and excluded participants in any of the variables (p's > 257, data not shown).

## MEASURES

Cognitive flexibility and control of impulsive responses were assessed with a computerized version of the Wisconsin Card Sorting Test (WSCT) (23). Four stimulus cards with different symbols (which differ in color, number or shape) are presented on the computer screen. Participants are instructed to match a response card with one of the four stimulus cards according to a criterion. Participants are given feedback after each response about whether the match is right or wrong. Matching criteria are changed after ten correct responses. The test ends when all 128 response cards have been presented. Different scores can be calculated. In this study, the three most widely used indexes were calculated: "total categories completed", "perseverative errors", and "the total number of errors".

Decision-making ability was assessed by a computerized version of the Iowa Gambling Task (IGT) (24). This instrument was designed to assess risk preferences by simulating real-life decision-making using uncertainty, rewards, and punishment. The goal of the task is to win as much money as possible by choosing cards from four decks. Two decks (A and B) are disadvantageous or high-risk decks, which provide high immediate gain, but larger future losses. The other two decks (C and D) are advantageous or low-risk decks, which provide less immediate gain, but smaller future losses. The task consists of 100 choices divided into five blocks of 20 choices each, and provides a global score and a score for each block, making it possible to observe whether the participant learns throughout the task.

Central coherence was assessed by the Group Embedded Figures Test (GEFT) (25), a task assessing the tendency to focus on details or to pay attention to the whole. The task includes 25 items divided into three sections. The first section is used for practice. The second and third sections include nine items each during five minutes. Participants are to locate a simple figure hidden within a complex figure. Following the instructions provided in the manual, the simple and complex figures were not presented simultaneously. The scoring is the sum of the correct guesses (maximum 18) from sections 2 and 3.

Pre-morbid intelligence was assessed with the Spanish version of the Kaufman Brief Intelligence Test (K-BIT) (26), which provides a verbal IQ, a non-verbal IQ, and a total IQ with a mean of 100 (SD = 15).

The Positive and Negative Affect Schedule (PANAS) (27) is a self-report scale that assesses general positive (e.g., interested) and negative (e.g., guilty) mood states. The 20 items are rated on five-point Likert-type scales (ranging from 1-not at all, to 5-extremely). In the present study, Cronbach's $\alpha$ values for PANAS-PA and PANAS-NA were 0.89 and 0.91, respectively.

Emotion regulation was assessed with the Spanish adaptationz of the Difficulties in Emotion Regulation Scale (DERS) (28,29). This scale includes 28 five-point Likert-type items for measuring the frequency of multiple dimensions of emotional regulation such as emotional understanding and clarity, and behavioral control. As the Spanish version gave one subscale less than the original version, the total score was analyzed to increase comparability. The Spanish DERS version has shown good validity and reliability for Spanish adult populations (30). Higher scores on the DERS indicate a higher frequency of emotion dysregulation.

## PROCEDURE

Clinical participants were consecutively referred to their respective health service units. Participants in the healthy group were recruited from under/post graduate courses at the University of (BLINDED) and by word-of-mouth. Participants included in this study completed the assessment in individual sessions. All participants gave written signed informed consent, and in accordance with the Declaration of Helsinki of 1975 as revised in 1983, the Ethics Committee of all the institutions involved in the project approved the study.

## STATISTICAL ANALYSIS

Differences between groups in continuous variables were analyzed with separate one-way ANCOVAs with age as covariate. Differences in the WCST variables were analyzed with a multivariate ANCOVA due to the intercorrelations between variables. Tukey's tests were used for post-hoc analyses. Effect sizes were assessed with partial eta-square ($h^2_p$), with values of 0.009, 0.058 and 0.138 indicating small, medium and large effect sizes respectively (Richardson, 2011).

The effects of IGT, WCST, GEFT, PANAS and age on DERS were analyzed with a stepwise linear regression. The linear regression provides a percent of explained variance of the criterion ($R^2$) and a beta coefficient with an associated p-value for each predictor. Assumptions of normality, linearity and homocedasticity of the residuals were examined with residual scatterplots (Tabachnick and Fidell, 2013). Significance was set at 0.01 after applying the false discovery rate (Narum, 2006) for 95 comparisons. This correction did not include the regression analysis, in which probability in = 0.05 and probability out = 0.10 were used. Statistical analyses were performed with SPSS v.22.

# RESULTS

## DEMOGRAPHICS

Groups differed significantly in age ($F = 26.56$, $p < 0.001$) and BMI ($F = 135.14$, $p < 0.001$), but not in IQ ($F = 1.98$, $p = 0.12$). The OB group was significantly older than all the groups, and the HC group was older than the RG (Table I). The same results were found for BMI, as expected.

## NEUROPSYCHOLOGICAL AND EMOTIONAL VARIABLES

The MANCOVA showed non-significant differences among groups (Pillais' trace = 0.061, $F[9,345] = 0.80$, $p = 0.617$, $\eta^2 = 0.02$) on the WCST variables. ANCOVA showed significant differences between groups on the IGT total score ($F[3,115] = 5.37$, $p = 0.002$, $\eta^2_p = 0.12$) and the GEFT ($F[3,115] = 4.85$, $p = 0.003$,

$\eta^2_p = 0.11$). All the clinical groups performed worse than the HCG group on the IGT and the GEFT (Table II).

Statistically significant differences were found between groups in PANAS-PA ($F[3,115] = 5.89$, $p = 0.001$, $\eta^2_p = 0.13$) and PANAS-NA ($F[3,115] = 13.26$, $p < 0.001$, $\eta^2_p = 0.26$), with both ED and OB groups scoring significantly lower in PANAS-PA, and both ED groups scoring higher in PANAS-NA compared to HCG and OB groups. Significant differences were also found between groups in DERS total score ($F(3,115) = 18.03$, $p < 0.001$, $\eta^2_p = 0.32$), with both ED groups and OB groups obtaining higher scores relative to the HCG, and with the BPG obtaining higher scores compared to OB group.

## REGRESSION ANALYSIS

The model predicting DERS was significant ($F = 40.88$, $p < 0.001$), with PANAS-PA ($b = -0.803$, $p = 0.001$), PANAS-NA ($b = 1.16$, $p < 0.001$) and IGT ($b = -0.152$, $p = 0.025$) accounting for 51.4% of the variance. Assumptions of normality, linearity and homocedasticity were deemed to be met according to the residual scatterplot (Fig. 1), with only a small number of outliers. Age had no additional effects on the prediction model ($F_{change}[1,115] = 3.38$, $p = 0.069$).

## DISCUSSION

This study analyzed the ability of neuropsychological variables to predict emotional regulation in eating and weight-related problems ranging from AN-restricting type to obesity. We found that both patients with ED and patients with obesity showed impairments in decision-making and central coherence compared to the HCG, and also that both affect (positive and negative) and cognitive variables predict emotional regulation.

When decision-making was analyzed, significant differences were found between both ED and OB and the HCG even after controlling for age. The analysis of the participants' performance curves revealed that clinical participants (OB, RG and BPG) failed to learn what choices they had to make in order to obtain benefits at the end of the task. These results are in line with those showing that ED patients make decisions based on immediate gains, despite negative long-term consequences (31,32). Previous research has linked poor decision-making found in obese patients to executive functions that regulate one's ability to inhibit short-term rewards (33,34), which could help to explain the long-standing pattern of failed weight loss attempts (8). We thus add some evidence that weight-related disorders show a tendency toward poor decision-making based on immediate rewards (7,9,32,35,36).

**Table I.** Demographic statistics

| | RG | | BPG | | OBG | | HCG | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| Age (years) | 22.80 | 8.05 | 25.50 | 9.02 | 45.39 | 12.35 | 30.36 | 11.95 |
| BMI | 17.36 | 1.99 | 21.46 | 2.32 | 41.92 | 9.69 | 21.56 | 1.99 |
| IQ | 102.93 | 7.31 | 101.94 | 8.31 | 105.33 | 8.62 | 106.90 | 9.36 |

*RG: restricting group; BPG: bingeing/purging group; OBG: obese group; HCG: healthy comparison group; BMI: body mass index; IQ: intelligence quotient.*

**Table II.** Neuropsychological variables

| | RG | | BPG | | OBG | | HCG | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| **WCST** | | | | | | | | |
| Categories | 5.57 | 1.33 | 5.44 | 1.46 | 4.12 | 2.47 | 5.44 | 1.37 |
| Pers. errors | 9.73 | 8.66 | 10.33 | 7.30 | 18.61 | 17.07 | 12.05 | 10.21 |
| N. errors | 20.40 | 15.74 | 21.83 | 17.04 | 38.64 | 30.03 | 22.44 | 16.65 |
| IGT | -3.27 | 14.72 | -5.50 | 24.63 | 5.03 | 20.89 | 15.54 | 27.39 |
| GEFT | 9.30 | 4.53 | 9.06 | 3.29 | 7.61 | 5.59 | 12.13 | 4.47 |
| **PANAS** | | | | | | | | |
| PA | 28.37† | 8.26 | 27.94† | 8.42 | 31.58 | 8.00 | 35.33 | 5.69 |
| NA | 25.63*,† | 10.23 | 30.22*,† | 8.87 | 19.39 | 8.15 | 15.87 | 6.74 |
| DERS | 80.07 | 22.98 | 89.28 | 21.06 | 62.51 | 20.02 | 51.79 | 13.29 |

*RG: restricting group; BPG: bingeing/purging group; OBG: obese group; HCG: healthy comparison group; WCST: Wisconsin Card Sorting Test; TOTAL: total categories completed; Pers. errors: perseverative errors; N. errors: number of errors; IGT: Iowa Gambling Task; GEFT: Group Embedded Figures Test; PANAS: Positive and Negative Affective Schedule; PA: positive affect; NA: negative affect; DERS: Difficulties in Emotion Regulation Scale. *Relative to OBG. †Relative to HCG.*

Central coherence results indicated that both the ED and OB groups showed a poor ability to identify correct shapes compared to the healthy controls. These data differ in part from studies where patients with AN (both subtypes) were found to be more efficient on tasks that require an analytic approach (16), but they confirm previous results reporting global integration difficulties in patients with obesity (7,17). Discrepancies could be explained by the use of different tests for central coherence assessment (matching familiar figures test, and embedded figures test, Rey-Osterrieth complex figure test) for assessing a complex, non-unitary construct (15), differences in task administration (18), and controlling for variables such as age or IQ and symptomatology subtypes of ED.

Consistent with previous studies (37-40), we found that both ED and OB groups had difficulties in emotion regulation. However, our study adds to the literature a relation between executive functioning and emotion regulation according to the 51.4% of the variance on the DERS accounted for by variables assessing positive and negative affect and also decision-making. Consistent with the relief component, we found that emotion dysregulation was positively associated with negative affect and negatively associated with positive affect. It has been reported that there may be a link between high food intakes and emotions in individuals with obesity as a strategy for releasing negative emotions (41). We believe that our study is the first one relating affect and executive dysfunction with emotion dysregulation, and also that our results are in line with previous studies relating positive affect and emotional eating (42).

Our results suggest that food-related behaviors directed to decreasing negative affect symptoms may be reinforced by an inability to inhibit behaviors focused on immediate rewards, thus reinforcing a vicious circle that impedes weight loss in individuals with obesity and that contributes to maintain weight loss in ED. This mechanism, similar for both ED and obesity, would differ in the specific behavior used to decreasing negative affect, with food intake in individuals with obesity or binge-eating disorders and food restriction and purges in purging-type AN. Our results support the recommendation of analyzing whether interventions focused on decision-making have an impact on psychological and physical outcomes in ED and obesity (8).

Some limitations must be stated. We analyzed weight related problems in a continuum from AD to obesity, with separate restricting and bingeing/purging groups. Thus, our results may not be comparable to those from samples labeled as restricting AN or binge/purging BN. The administration of cognitive variables differed slightly from previous studies, which could account partially for dissimilarities in results. Our results are only applicable to females with eating disorders, so further research is needed to test whether the same pattern applies to male individuals with eating disorders. Some of the strengths of this work are the large sample, and the use of validated cognitive variables in eating disorders (8,43,44) to predict emotional regulation. However, using only one test to measure decision-making lacks sensitivity to identify which of the cognitive, motivational or response components underlies impaired decision-making (43).

## CONCLUSIONS

Emotion regulation in eating disorders and obesity is associated with positive and negative affect as well as with decision-making, which have important clinical implications. The administration of tests and questionnaires measuring cognition and affect can help identify females with eating disorders at risk of pathological behaviors related to food. Identifying these patients will increase the possibility of including them in interventions focused on reducing eating pathology and increasing quality of life (12).

## REFERENCES


1. Volkow ND, Wang G-J, Tomasi D, Baler RD. Obesity and addiction: neurobiological overlaps: overlaps between drug and food addiction. Obes Rev 2013;14(1):2-18.
2. O'Hara CB, Campbell IC, Schmidt U. A reward-centred model of anorexia nervosa: a focused narrative review of the neurological and psychophysiological literature. Neurosci Biobehav Rev 2015;52:131-52.
3. Litwin R, Goldbacher EM, Cardaciotto L, Gambrel LE. Negative emotions and emotional eating: the mediating role of experiential avoidance. Eat Weight Disord 2017;22(1):97-104.
4. Haedt-Matt AA, Keel PK. Revisiting the affect regulation model of binge eating: A meta-analysis of studies using ecological momentary assessment. Psychol Bull 2011;137(4):660-81.
5. Spoor STP, Bekker MHJ, Van Strien T, Van Heck GL. Relations between negative affect, coping, and emotional eating. Appetite 2007;48(3):368-76.
6. Wu M, Brockmeyer T, Hartmann M, Skunde M, Herzog W, Friederich H-C. Reward-related decision making in eating and weight disorders: a systematic review and meta-analysis of the evidence from neuropsychological studies. Neurosci Biobehav Rev 2016;61:177-96.
7. Aloi M, Rania M, Caroleo M, Bruni A, Palmieri A, Cauteruccio MA, et al. Decision making, central coherence and set-shifting: a comparison between binge eating disorder, anorexia nervosa and healthy controls. BMC Psychiatry 2015;15(1). Cited Feb 23rd 2018. Available from: http://bmcpsychiatry.biomedcentral.com/articles/10.1186/s12888-015-0395-z
8. Brogan A, Hevey D, Pignatti R. Anorexia, bulimia, and obesity: Shared decision making deficits on the Iowa Gambling Task (IGT). J Int Neuropsychol Soc 2010;16(4):711-5.
9. Perpiñá C, Segura M, Sánchez-Reales S. Cognitive flexibility and decision-making in eating disorders and obesity. Eat Weight Disord 2017;22(3):435-44.
10. Fagundo AB, De la Torre R, Jiménez-Murcia S, Agüera Z, Granero R, Tárrega S, et al. Executive functions profile in extreme eating/weight conditions: from anorexia nervosa to obesity. PLoS ONE 2012;7(8):e43382.
11. Wu M, Brockmeyer T, Hartmann M, Skunde M, Herzog W, Friederich H-C. Set-shifting ability across the spectrum of eating disorders and in overweight and obesity: a systematic review and meta-analysis. Psychol Med 2014;44(16):3365-85.
12. Tchanturia K, Lounes N, Holttum S. Cognitive remediation in anorexia nervosa and related conditions: a systematic review: CRT in anorexia. Eur Eat Disord Rev 2014;22(6):454-62.
13. Mobbs O, Iglesias K, Golay A, Van der Linden M. Cognitive deficits in obese persons with and without binge eating disorder. Investigation using a mental flexibility task. Appetite 2011;57(1):263-71.
14. López CA, Tchanturia K, Stahl D, Treasure J. Central coherence in women with bulimia nervosa. Int J Eat Disord 2008;41(4):340-7.
15. Darcy AM, Fitzpatrick KK, Manasse SM, Datta N, Klabunde M, Colborn D, et al. Central coherence in adolescents with bulimia nervosa spectrum eating disorders: central coherence in adolescent bulimia. Int J Eat Disord 2015;48(5):487-93.
16. Weider S, Indredavik MS, Lydersen S, Hestad K. Central coherence, visuoconstruction and visual memory in patients with eating disorders as measured by different scoring methods of the Rey Complex Figure test: performance on the RCFT in ED patients. Eur Eat Disord Rev 2016;24(2):106-13.
17. Roberts ME, Tchanturia K, Treasure JL. Is attention to detail a similarly strong candidate endophenotype for anorexia nervosa and bulimia nervosa? World J Biol Psychiatry 2013;14(6):452-63.

18. Lang K, Stahl D, Espie J, Treasure J, Tchanturia K. Set shifting in children and adolescents with anorexia nervosa: an exploratory systematic review and meta-analysis. Int J Eat Disord 2014;47(4):394-9.
19. American Psychiatric Association. Diagnostic and statistical manual of mental disorders (5th ed.). American Psychiatric Association, editor. Arlington, VA: American Psychiatric Publishing; 2013.
20. First MB, Spitzer RL, Gibbon M, Williams JBW. Structured Clinical Interview for DSM-IV-TR Axis I Disorders, Research Version, Patient Edition. (SCID-I/P). New York: Biometrics Research, New York State Psychiatric Institute; 2002
21. Van Autreve S, De Baene W, Baeken C, Van Heeringen C, Vervaet M. Do restrictive and bingeing/purging subtypes of anorexia nervosa differ on central coherence and set shifting? Eur Eat Disord Rev 2013;21(4):308-14.
22. Tabachnick BG, Fidell LS. Using multivariate statistics. 6th ed. New Jersey: Pearson Education Inc; 2013.
23. Tien AY, Spevack TV, Jones DW, Pearlson GD, Schlaepfer TE, Strauss ME. Computerized Wisconsin Card Sorting Test: comparison with manual administration. Kaohsiung J Med Sci 1996;12(8):479-85.
24. Bechara A, Damasio AR, Damasio H, Anderson SW. Insensitivity to future consequences following damage to human prefrontal cortex. Cognition 1994;50(1-3):7-15.
25. Witkin H, Ohman P, Raskin E, Karp S. Embedded figures test. Palo Alto, CA: Consulting Psychologist; 1997.
26. Kaufman AS, Kaufman NL. Test breve de inteligencia (K-BIT: Kaufman-Brief Intelligence Test). Madrid, Spain: TEA Ediciones; 2006.
27. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. J Pers Soc Psychol 1988;54(6):1063-70.
28. Gratz KL, Roemer L. Multidimensional assessment of emotion regulation and dysregulation: development, factor structure, and initial validation of the Difficulties in Emotion Regulation Scale. J Psychopathol Behav Assess 2004;26(1):41-54.
29. Hervás G, Jódar R. The Spanish version of the Difficulties in Emotion Regulation Scale. Clínica Salud 2008;19(2):139-56.
30. Wolz I, Agüera Z, Granero R, Jiménez-Murcia S, Gratz KL, Menchón JM, et al. Emotion regulation in disordered eating: psychometric properties of the Difficulties in Emotion Regulation Scale among Spanish adults and its interrelations with personality and clinical severity. Front Psychol 2015;6. Cited Mar 16th 2018. Available from: http://journal.frontiersin.org/Article/10.3389/fpsyg.2015.00907/abstract
31. Chan TWS, Ahn W-Y, Bates JE, Busemeyer JR, Guillaume S, Redgrave GW, et al. Differential impairments underlying decision making in anorexia nervosa and bulimia nervosa: a cognitive modeling analysis: decision-making in anorexia and bulimia. Int J Eat Disord 2014;47(2):157-67.
32. Mallorquí-Bagué N, Fagundo AB, Jiménez-Murcia S, De la Torre R, Baños RM, Botella C, et al. Decision making impairment: a shared vulnerability in obesity, gambling disorder and substance use disorders? PLoS ONE 2016;11(9):e0163901.
33. Davis C, Levitan RD, Muglia P, Bewell C, Kennedy JL. Decision-making deficits and overeating: a risk model for obesity. Obes Res 2004;12(6):929-35.
34. Pignatti R, Bertella L, Albani G, Mauro A, Molinari E, Semenza C. Decision-making in obesity: a study using the Gambling Task. Eat Weight Disord 2006;11(3):126-32.
35. Matsumoto J, Hirano Y, Numata N, Matzuzawa D, Murano S, Yokote K, et al. Comparison in decision-making between bulimia nervosa, anorexia nervosa, and healthy women: influence of mood status and pathological eating concerns. J Eat Disord 2015;3(1). Cited Apr 23rd 2018. Available from: http://jeatdisord.biomedcentral.com/articles/10.1186/s40337-015-0050-6
36. Davis C, Patte K, Curtis C, Reid C. Immediate pleasures and future consequences. A neuropsychological study of binge eating and obesity. Appetite 2010;54(1):208-13.
37. Brockmeyer T, Skunde M, Wu M, Bresslein E, Rudofsky G, Herzog W, et al. Difficulties in emotion regulation across the spectrum of eating disorders. Compr Psychiatry 2014;55(3):565-71.
38. Kass AE, Wildes JE, Coccaro EF. Identification and regulation of emotions in adults of varying weight statuses. J Health Psychol 2017;135910531668960.
39. Ruscitti C, Rufino K, Goodwin N, Wagner R. Difficulties in emotion regulation in patients with eating disorders. Borderline Personal Disord Emot Dysregulation 2016;3(1). Cited 16th Mar 2018. Available from: http://bpded.biomedcentral.com/articles/10.1186/s40479-016-0037-1
40. Zijlstra H, Van Middendorp H, Devaere L, Larsen JK, Van Ramshorst B, Geenen R. Emotion processing and regulation in women with morbid obesity who apply for bariatric surgery. Psychol Health 2012;27(12):1375-87.
41. Leehr EJ, Krohmer K, Schag K, Dresler T, Zipfel S, Giel KE. Emotion regulation model in binge eating disorder and obesity - A systematic review. Neurosci Biobehav Rev 2015;49:125-34.
42. Sultson H, Kukk K, Akkermann K. Positive and negative emotional eating have different associations with overeating and binge eating: construction and validation of the Positive-Negative Emotional Eating Scale. Appetite 2017;116:423-30.
43. Guillaume S, Gorwood P, Jollant F, Van den Eynde F, Courtet P, Richard-Devantoy S. Impaired decision-making in symptomatic anorexia and bulimia nervosa patients: a meta-analysis. Psychol Med 2015;45(16):3377-91.
44. Tchanturia K, Davies H, Roberts M, Harrison A, Nakazato M, Schmidt U, et al. Poor cognitive flexibility in eating disorders: examining the evidence using the Wisconsin Card Sorting Task. PLoS ONE 2012;7(1):e28331.